Express Mail Label No. **HAND DELIVERED**

NEW UTILITY PATENT APPLICATION TRANSMITTAL (Large Entity)

(Only for new nonprovisional applications under 37 CFR 1.53(b))

Docket No.
NU-98035

Total Pages in this Submission

Jc595 U.S. PTO 11/24/98

JC551 U.S. PTO 09/198376 11/24/98

TO THE ASSISTANT COMMISSIONER FOR PATENTS
Box Patent Application
Washington, D.C. 20231

Transmitted herewith for filing under 35 U.S.C. 111(a) and 37 C.F.R. 1.53(b) is a new utility patent application for an invention entitled:

HEAT CONTROL DEVICE

and invented by:

Akira Okamoto, Yuichi Shimakawa and Takashi Manako

If a CONTINUATION APPLICATION, *check appropriate box and supply the requisite information:*

☐ **Continuation** ☐ **Divisional** ☐ **Continuation-in-part (CIP)** of prior application No.: ______

Enclosed are:

Application Elements

1. ☒ Filing fee as calculated and transmitted as described below
2. ☒ Specification having **14** pages and including the following:
   - a. ☒ Descriptive Title of the Invention
   - b. ☐ Cross References to Related Applications *(if applicable)*
   - c. ☐ Statement Regarding Federally-sponsored Research/Development *(if applicable)*
   - d. ☐ Reference to Microfiche Appendix *(if applicable)*
   - e. ☒ Background of the Invention
   - f. ☒ Brief Summary of the Invention
   - g. ☒ Brief Description of the Drawings *(if drawings filed)*
   - h. ☒ Detailed Description
   - i. ☒ Claim(s) as Classified Below
   - j. ☒ Abstract of the Disclosure
3. ☒ Drawing(s) *(when necessary as prescribed by 35 USC 113)*
   - a. ☐ Formal
   - b. ☒ Informal

   Number of Sheets **4**

NEW UTILITY PATENT APPLICATION TRANSMITTAL (Large Entity) *(Only for new nonprovisional applications under 37 CFR 1.53(b))*	Docket No. **NU-98035**
	Total Pages in this Submission

Application Elements (Continued)

4. ☒ Oath or Declaration
   - a. ☒ Newly executed *(original or copy)* ☐ Unexecuted
   - b. ☐ Copy from a prior application (37 CFR 1.63(d)) *(for continuation/divisional application only)*
   - c. ☒ With Power of Attorney ☐ Without Power of Attorney

5. ☐ Incorporation By Reference *(usable if Box 4b is checked)*
   The entire disclosure of the prior application, from which a copy of the oath or declaration is supplied under Box 4b, is considered as being part of the disclosure of the accompanying application and is hereby incorporated by reference therein.

6. ☐ Computer Program in Microfiche *(Appendix)*

7. ☐ Nucleotide and/or Amino Acid Sequence Submission *(if applicable, all must be included)*
   - a. ☐ Paper Copy
   - b. ☐ Computer Readable Copy *(identical to computer copy)*
   - c. ☐ Statement Verifying Identical Paper and Computer Readable Copy

Accompanying Application Parts

8. ☐ Assignment Papers *(cover sheet & document(s))*

9. ☐ 37 CFR 3.73(B) Statement *(when there is an assignee)*

10. ☐ English Translation Document *(if applicable)*

11. ☐ Information Disclosure Statement/PTO-1449 ☐ Copies of IDS Citations

12. ☐ Preliminary Amendment

13. ☒ Acknowledgment postcard

14. ☐ Certificate of Mailing

    ☐ First Class ☐ Express Mail *(Specify Label No.)*: **HAND DELIVERED**

15. ☐ Certified Copy of Priority Document(s) *(if foreign priority is claimed)*

NEW UTILITY PATENT APPLICATION TRANSMITTAL (Large Entity)	Docket No. NU-98035
(Only for new nonprovisional applications under 37 CFR 1.53(b))	Total Pages in this Submission

Accompanying Application Parts (Continued)

16. ☐ Additional Enclosures *(please identify below)*:

Fee Calculation and Transmittal

CLAIMS AS FILED

For	#Filed	#Allowed	#Extra		Rate	Fee
Total Claims	29	- 20 =	9	x	$18.00	$162.00
Indep. Claims	2	- 3 =	0	x	$78.00	$0.00
Multiple Dependent Claims (check if applicable) ☐						$0.00
					BASIC FEE	$760.00
OTHER FEE *(specify purpose)*						$0.00
					TOTAL FILING FEE	$922.00

☒ A check in the amount of $922.00 to cover the filing fee is enclosed.

☒ The Commissioner is hereby authorized to charge and credit Deposit Account No. 23-1951 as described below. A duplicate copy of this sheet is enclosed.

- ☐ Charge the amount of as filing fee.
- ☒ Credit any overpayment.
- ☒ Charge any additional filing fees required under 37 C.F.R. 1.16 and 1.17.
- ☐ Charge the issue fee set in 37 C.F.R. 1.18 at the mailing of the Notice of Allowance, pursuant to 37 C.F.R. 1.311(b).

Dated: **November 24, 1998**

Signature

C. Lamont Whitham
Reg. No. 22,424

Whitham, Curtis & Whitham
Reston International Center
11800 Sunrise Valley Drive, Suite 900
Reston, VA 20191
(703)391-2510

cc:

 P01ULRG/REV04

LAW OFFICES
WHITHAM, CURTIS & WHITHAM
A PROFESSIONAL CORPORATION
INTELLECTUAL PROPERTY LAW
11800 SUNRISE VALLEY DRIVE, SUITE 900
RESTON, VIRGINIA 20191

APPLICATION FOR UNITED STATES LETTERS PATENT

Applicants: Akira Okamoto, Yuichi Shimakawa and Takashi Nanako
For: HEAT CONTROL DEVICE
Docket No.: NU-98035

APPLICATION
FOR
UNITED STATES PATENT

To Whom It May Concern:

BE IT KNOWN that We, Akira OKAMOTO, Yuichi SHIMAKAWA and Takashi MANAKO, citizens of Japan, all residing at c/o NEC Corporation, 7-1, Shiba 5-chome, Minato-ku, Tokyo, Japan, have made a new and useful improvement in "HEAT CONTROL DEVICE" of which the following is the true, clear and exact specification, reference being had to the accompanying drawings.

HEAT CONTROL DEVICE

BACKGROUND OF THE INVENTION

The present invention relates to a heat control device and more particularly to a heat control device feasible for, e.g., an artificial satellite or a spacecraft.

As for a spacecraft expected to navigate a vacuum environment, heat radiation from outside surfaces is the only heat radiating means available. The amount of heat radiation dictates the temperature inside the spacecraft. A thermal louver has customarily been used for maintaining temperature inside the spacecraft adequate. The thermal louver adjusts the amount of heat radiation to the outside in accordance with temperature. Specifically, the louver includes a bimetal or similar actuator for driving blades. The blades are movable to increase or decrease the effective area and therefore the temperature of heat radiation surfaces, i.e., increase the amount of heat radiation at a high temperature or reduces it at a low temperature.

However, the above thermal louver is a mechanical device including movable portions and therefore bulky and heavy. Moreover, the louver lacks in reliability due to the movable portions. In addition, the blades cannot be opened and closed more than a

preselected number of times due to their limited life.

Technologies relating to the present invention are also disclosed in, e.g., Japanese Patent Laid-Open Publication Nos. 63-207799, 1-212699 and 9-58600.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide a reliable heat control device operable over a long period of time even in a severe environment and easy to produce.

It is another object of the present invention to provide a reliable, small size and light weight heat control device including no movable portions.

In a heat control device of the present invention, a variable-phase substance exhibiting a property of an insulator or a property of metal in a high temperature phase or a low temperature phase, respectively, and radiating a great amount of heat or a small amount of heat in the low temperature phase or the high temperature phase, respectively, controls the temperature of a desired object.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features and advantages of the present invention will become more apparent from the following detailed description taken with the accompanying drawings in which:

FIG. 1 shows a conventional thermal louver;

FIG. 2 is a graph showing a reflection spectrum particular to

a variable-phase substance $La_{1-x}Sr_xMnO_3$ applicable to the present invention;

FIG. 3 is a graph showing resistivity

FIG. 4 is a graph showing data representative of the reflectivity of $La_{1-x}Sr_xMnO_3$; and

FIGS. 5 and 6 respectively show a first and a second embodiment of the heat control device in accordance with the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

To better understand the present invention, brief reference will be made to a conventional thermal louver, shown in FIG. 1. The thermal louver to be described adjusts the amount of heat radiation to the outside in accordance with temperature, as stated earlier. As shown, the thermal louver includes a bimetal or actuator 10 and blades 12. The bimetal 10 drives the blade 12 in order to increases or decreases the effective area and therefore the temperature of heat radiation surfaces. There are also shown in FIG. 1 a frame 14, a bimetal housing 16, shafts 18, and bearings 20.

A heat control device in accordance with the present invention is characterized in that it uses a heat radiation characteristic particular to a substance itself in place of a mechanical principle. As for a spacecraft expected to navigate a vacuum environment, heat radiation from outside surfaces is the only heat radiating means available. The amount of heat radiation dictates the temperature inside the spacecraft.

The heat control device of the present invention is implemented by a variable-phase substance ($La_{1-x}Sr_xMnO_3$) arranged on the heat radiation surfaces of a spacecraft. The variable-phase substance belongs to a family of oxides of perovskite Mn and undergoes phase transition around room temperature. The characteristic of this kind of substance is similar to the characteristic of metal in a low temperature phase, but similar to the characteristic of an insulator in a high temperature phase. Also, the heat radiation ratio of the substance is low when conductivity is high, but high when conductivity is low. The substance therefore has an automatic temperature adjusting ability, *i.e.*, automatically increases its heat radiation ratio at high temperatures and decreases it at low temperatures. FIG. 1 shows the dependency of the resistivity and infrared reflectivity of $La_{1-x}Sr_xMnO_3$ on temperature, reported in the past. As FIG. 2 indicates, the reflectivity noticeably changes with changes in temperature around photon energy of about 0.12 eV (10 μm) which is the peak of heat radiation around room temperature. The phase transition temperature is variable between 250 K and 350 K in accordance with the composition ratio x of La and Sr.

FIG. 3 shows data representative of the hemispherical reflectivity of $La_{0.825}Sr_{0.175}MnO_3$ and measured in the range of from 170 K to 380 K. As shown, the reflectivity sharply changes in the range of from 300 K to 280 K, i.e., at the phase transition temperatures. As a result, the above substance exhibits the characteristic of metal at the low temperature side, but exhibits the characteristic of an

insulator at the high temperature side.

FIG. 4 shows data representative of the result of measurement of resistivity. As shown, the resistivity changes by about four times as in FIG. 2.

In the heat control device of the present invention, the variable-phase substance should only be arranged on heat radiation surfaces in the form of a film and is therefore space-saving and light weight. Moreover, the device is highly reliable because it needs no movable portions. When the device is mounted in a position getting the sunlight, a silicon plate transparent for thermal infrared rays, but opaque for the sunlight, may be positioned in front of the variable-phase substance in order to minimize the sunlight absorption of the device.

For the variable-phase substance, use may be made of an oxide of Mn-containing perovskite represented by $A_{1-x}B_xMnO_3$ where A denotes at least one of La, Pr, Nd and Sm rare earth ions, and B denotes at least one of Ca, Sr and Ba alkaline rare earth ions. Further, such a substance may be implemented by an oxide of Cr-containing corundum vanadium, preferably $(V_{1-x}Cr_x)_2O_3$.

Referring to FIG. 5, a first embodiment of the heat control device in accordance with the present invention will be described. As shown, the device is implemented by a variable-phase substance 1 for controlling the temperature of a desired object 2. The substance 1 exhibits the characteristic of metal in a high temperature phase, but exhibits the characteristic of an insulator in a low temperature

phase. Also, the substance 1 radiates a great amount of heat in the high temperature phase, but radiates a small amount of heat in a low temperature phase. The substance 1 is affixed to the object 2 by powder coating, evaporation, crystalline adhesion or similar affixing means. In the illustrative embodiment, the substance 1 is implemented by $La_{1-x}Sr_xMnO_3$ belonging to a family of oxides of perovskite Mn.

Specifically, the object 2 is representative of the heat radiation wall of a spacecraft. The substance 1 is arranged on the surface 3 of the wall 2 in the form of a several hundred micron thick film. The substance 1 is thermally coupled to the surface 3 and substantially the same in temperature as the wall 2.

In operation, when the temperature of the surface 3 rises and heats the substance above the phase transition temperature, then the heat radiation ratio of the substance increases. As a result, the amount of heat radiation to the outside environment increases and lowers the temperature of the surface 3. Conversely, when the temperature of the surface 3 drops and cools off the substance below the phase transition temperature, the heat radiation ratio of the substance 1 and therefore the amount of heat radiation decreases, raising the temperature of the surface 3. With this mechanism, the substance 1 automatically controls the temperature of the surface 3 to a range around its phase transition temperature.

The substance 1 has a cubic crystal structure and has an optical property not dependent on the orientation of the

crystallographic axis. It follows that the substance 1 can be arranged on the surface 3 by any one of conventional schemes including powder coating, evaporation, crystalline adhesion and other affixing means and the adhesion of a film implemented by a powdery phase-variable substance containing, e.g., a binder.

The illustrative embodiment is practicable only if the variable-phase substance is implemented by, e.g., an oxide of Mn-containing perovskite represented by $A_{1-x}B_xMnO_3$ where A denotes at least one of La, Pr, Nd and Sm rare earth ions, and B denotes at least one of Ca, Sr and Ba alkaline rare earth ions. Further, such a substance may be implemented by an oxide of Cr-containing corundum vanadium, preferably $(V_{1-x}Cr_x)_2O_3$.

A second embodiment of the heat control device in accordance with the present invention will be described with reference to FIG. 6. As shown, the device is also implemented by the variable-phase substance 1 for controlling the temperature of the object 2. The substance 1 exhibits the characteristic of metal in a high temperature phase, but exhibits the characteristic of an insulator in a low temperature phase, as stated earlier. In addition, the substance 1 radiates a great amount of heat in the high temperature phase, but radiates a small amount of heat in a low temperature phase, as also stated previously. In the illustrative embodiment, a silicon plate 4 transparent for infrared rays, but opaque for visible rays, is positioned on the substance 1.

As shown in FIG. 2, $La_{1-x}Sr_xMnO_3$ constituting the substance 1

has reflectively as low as about 0.2 in the sunlight wavelength range (0.3 μm to 2.5 μm), i.e., it shows high absorbance to the sunlight in such a range. Therefore, when the substance is positioned in an area directly getting the sunlight, its absorbance is increased to obstruct heat radiation. In such a case, as shown in FIG. 6, the silicon plate 4 transparent for infrared rays, but opaque for visible rays, is mounted on the front of the substance 1. This embodiment is therefore identical in principle with the first embodiment except that the silicon plate 4 reflects the sunlight.

If desired, the silicon plate 4 may be replaced with any other member, e.g., a plate or a film containing germanium so long as it can transmit infrared rays.

In summary, it will be seen that the present invention provides a small size, light weight heat control device using an optical property particular to a substance itself in place of a mechanical principle applied to a conventional thermal louver. In addition, the device of the present invention is highly reliable and long life because it needs no movable portions which would bring about wear, fatigue and other problems.

Various modifications will become possible for those skilled in the art after receiving the teachings of the present disclosure without departing from the scope thereof.

What is claimed is:

1. In a heat control device, a variable-phase substance exhibiting a property of an insulator or a property of metal in a high temperature phase or a low temperature phase, respectively, and radiating a great amount of heat or a small amount of heat in the low temperature phase or the high temperature phase, respectively, controls a temperature of an object.

2. A heat control device as claimed in claim 1, wherein said variable-phase substance comprises an oxide of perovskite Mn.

3. A heat control device as claimed in claim 2, wherein the oxide of perovskite Mn comprises an oxide of Mn-containing perovskite represented by $A_{1-x}B_xMnO_3$ where A is at least one of La, Pr, Nd and Sm rare earth ions, and B is at least one of Ca, Sr and Ba alkaline rare earth ions.

4. A heat control device as claimed in claim 3, wherein said variable-phase substance is affixed to the object by powder coating, evaporation, crystalline adhesion or adhesion of a film formed of a variable-phase substance containing a binder.

5. A heat control device as claimed in claim 4, further comprising either one of a plate and a film mounted on said phase-variable substance for transmitting infrared rays and reflecting visible rays.

6. A heat control device as claimed in claim 5, wherein the object comprises either one of an artificial satellite and a

spacecraft.

7. A heat control device as claimed in claim 1, wherein the oxide of perovskite Mn comprises an oxide of Mn-containing perovskite represented by $A_{1-x}B_xMnO_3$ where A is at least one of La, Pr, Nd and Sm rare earth ions, and B is at least one of Ca, Sr and Ba alkaline rare earth ions.

8. A heat control device as claimed in claim 7, wherein said variable-phase substance is affixed to the object by powder coating, evaporation, crystalline adhesion or adhesion of a film formed of a variable-phase substance containing a binder.

9. A heat control device as claimed in claim 8, further comprising either one of a plate and a film mounted on said phase-variable substance for transmitting infrared rays and reflecting visible rays.

10. A heat control device as claimed in claim 9, wherein the object comprises either one of an artificial satellite and a spacecraft.

11. A heat control device as claimed in claim 1, wherein said variable-phase substance comprises an oxide of Cr-containing corundum vanadium.

12. A heat control device as claimed in claim 11, wherein said variable-phase substance comprises $(V_{1-x}Cr_x)_2O_3$.

13. A heat control device as claimed in claim 12, wherein said variable-phase substance is affixed to the object by powder coating, evaporation, crystalline adhesion or adhesion of a film formed of a

variable-phase substance containing a binder.

14. A heat control device as claimed in claim 13, further comprising either one of a plate and a film mounted on said phase-variable substance for transmitting infrared rays and reflecting visible rays.

15. A heat control device as claimed in claim 14 wherein the object comprises either one of an artificial satellite and a spacecraft.

16. A heat control device as claimed in claim 1, wherein said variable-phase substance comprises $(V_{1-x}Cr_x)_2O_3$.

17. A heat control device as claimed in claim 16, wherein said variable-phase substance is affixed to the object by powder coating, evaporation, crystalline adhesion or adhesion of a film formed of a variable-phase substance containing a binder.

18. A heat control device as claimed in claim 17, further comprising either one of a plate and a film mounted on said phase-variable substance for transmitting infrared rays and reflecting visible rays.

19. A heat control device as claimed in claim 18, wherein the object comprises either one of an artificial satellite and a spacecraft.

20. A heat control device as claimed in claim 1, wherein said variable-phase substance is affixed to the object by powder coating, evaporation, crystalline adhesion or adhesion of a film formed of a variable-phase substance containing a binder.

21. A heat control device as claimed in claim 20, further comprising either one of a plate and a film mounted on said phase-variable substance for transmitting infrared rays and reflecting visible rays.

22. A heat control device as claimed in claim 21, wherein the object comprises either one of an artificial satellite and a spacecraft.

23. A heat control device as claimed in claim 1, further comprising either one of a plate and a film mounted on said phase-variable substance for transmitting infrared rays and reflecting visible rays.

24. A heat control device as claimed in claim 23, wherein the object comprises either one of an artificial satellite and a spacecraft.

25. A heat control device as claimed in claim 23, wherein the object comprises either one of an artificial satellite and a spacecraft.

26. In a method of controlling a temperature of an object, a variable-phase substance exhibiting a property of an insulator or a property of metal in a high temperature phase or a low temperature phase, respectively, and radiating a great amount of heat or a small amount of heat in the low temperature phase or the high temperature phase, respectively, is affixed to said object.

27. A method as claimed in claim 26, wherein the object comprises either one of an artificial satellite and a spacecraft.

28. A method as claimed in claim 26, wherein said variable-phase substance comprises either one of an oxide of perovskite Mn and an oxide of Cr-containing corundum vanadium.

29. A method as claimed in claim 28, wherein the object comprises either one of an artificial satellite and a spacecraft.

ABSTRACT

A small size, light weight heat control device feasible for an artificial satellite or a spacecraft is disclosed. The heat control device uses an optical property particular to a substance itself in place of a mechanical principle applied to a conventional thermal louver. In addition, the device of the present invention is highly reliable and long life because it needs no movable portions which would bring about wear, fatigue and other problems.

N-98035 FIGS. 1 – 6

FIG. 1 PRIOR ART

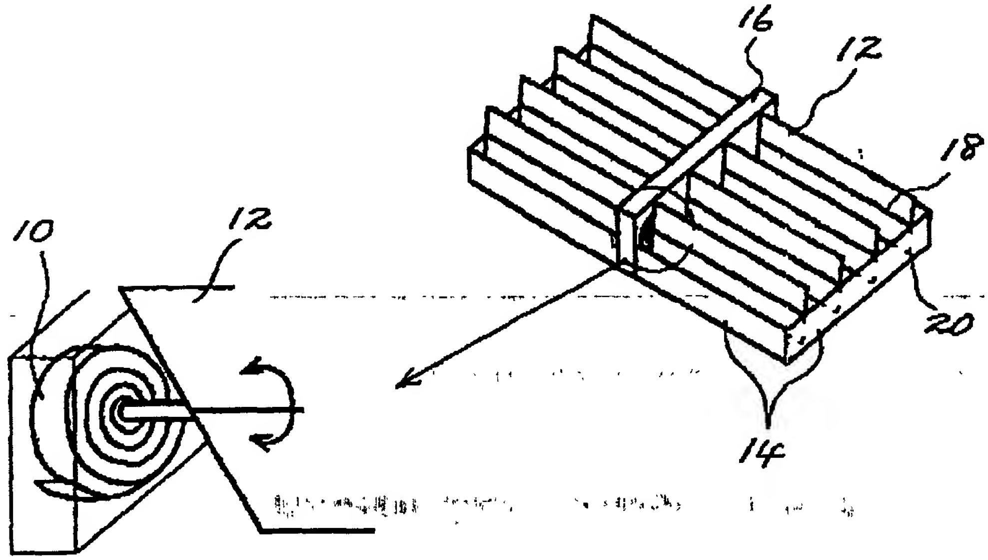


FIG. 2

Reflection Spectrum of La1-xSrxMnO3

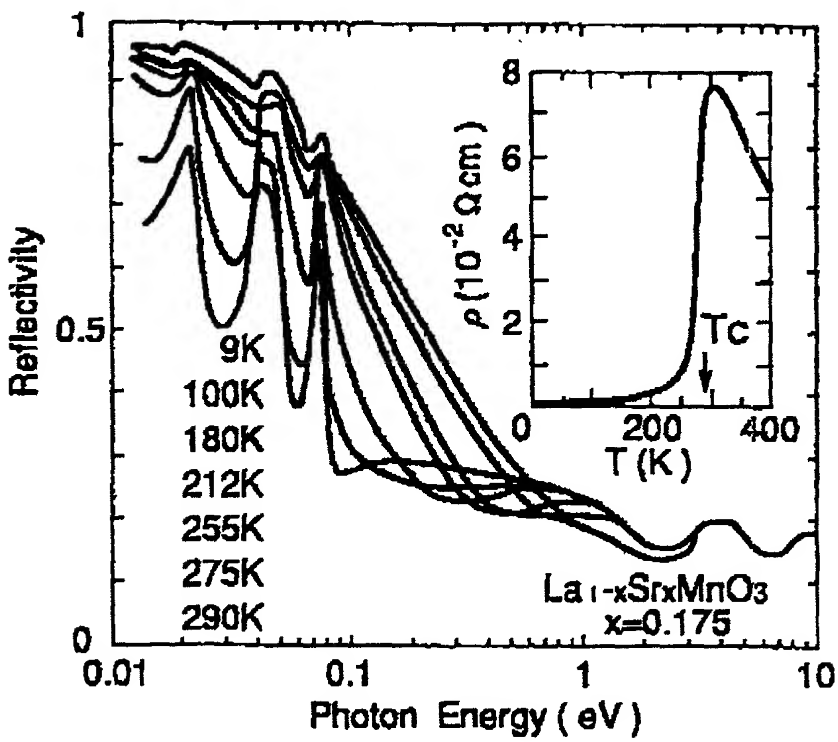


FIG.3

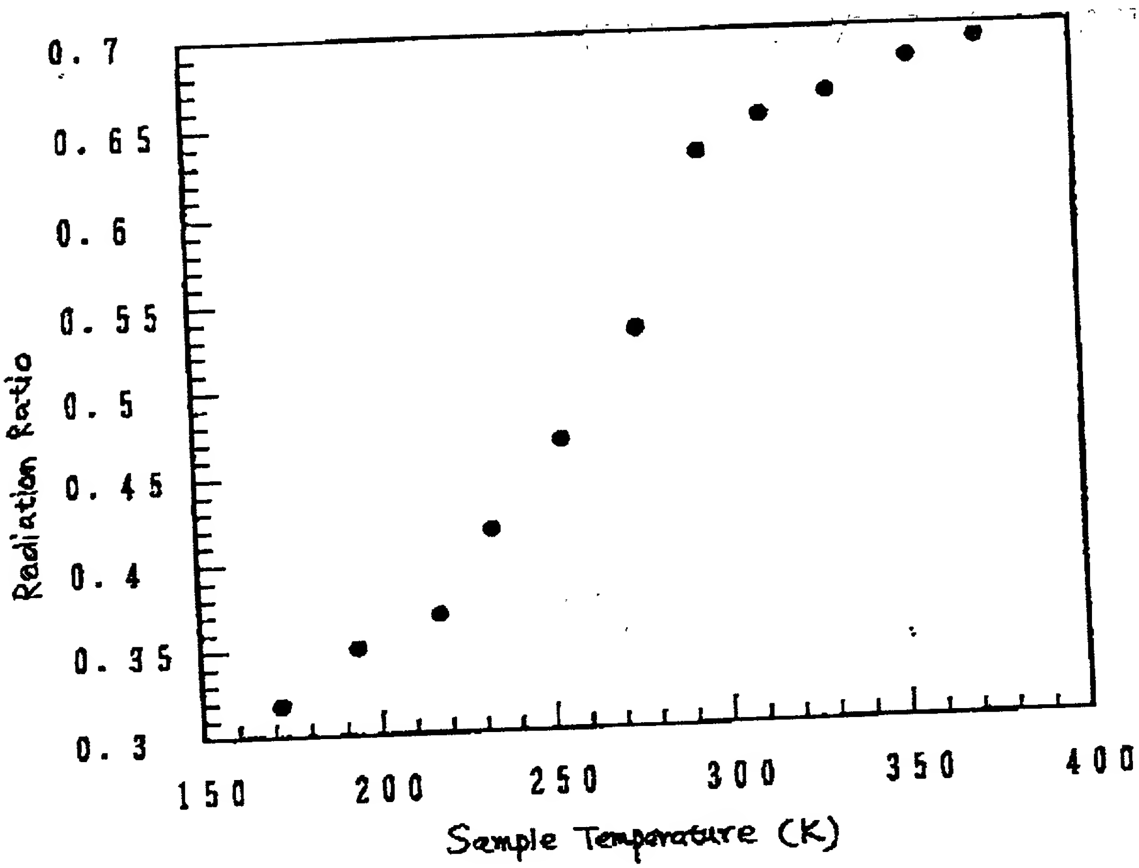
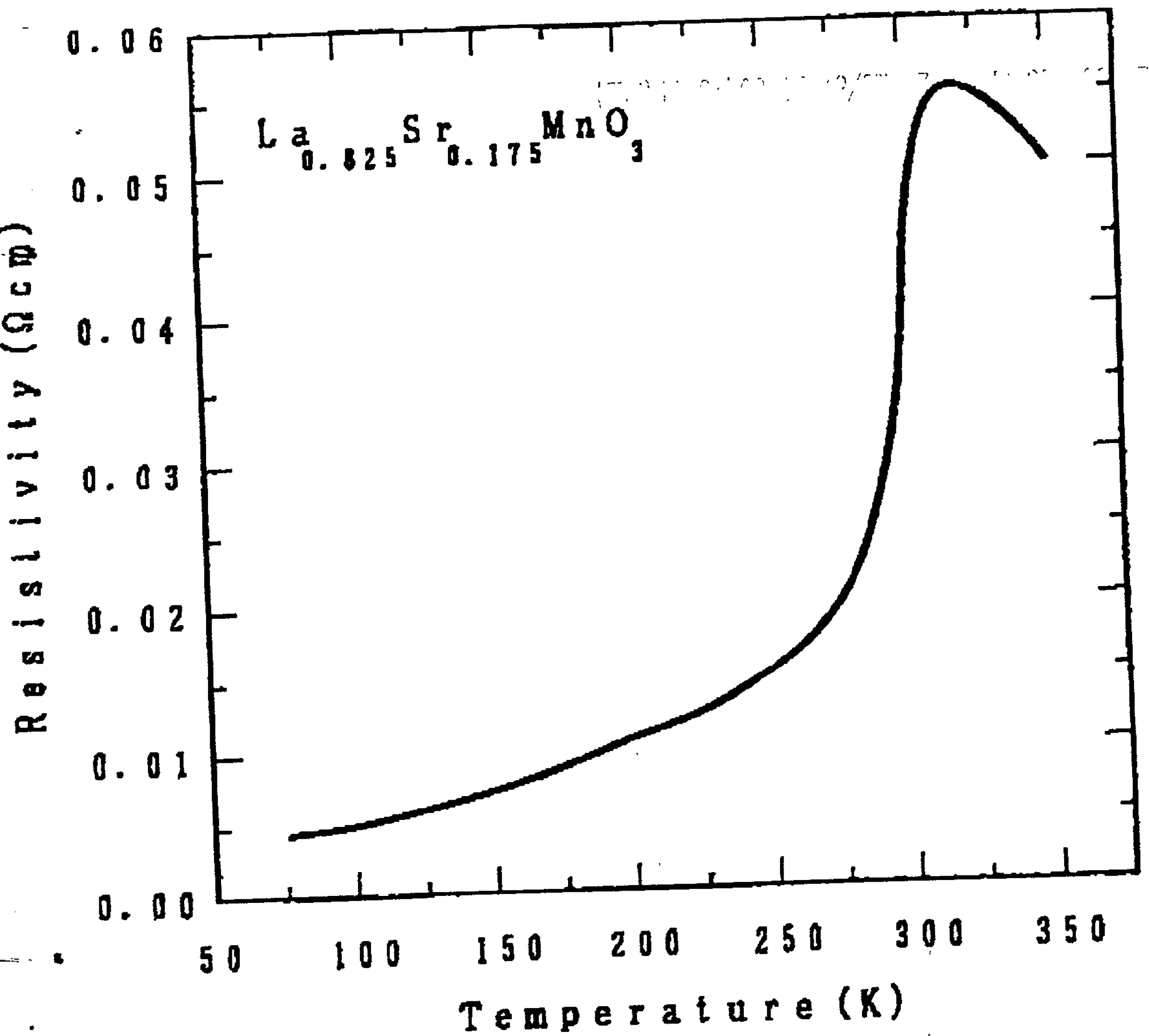

0. 7
0. 65
0. 6
0. 55
0. 5
0. 45
0. 4
0. 35
0. 3
Radiation Ratio
150
200
250
300
350
400
Sample Temperature (K)

FIG. 4



$La_{0.825}Sr_{0.175}MnO_3$
Resistivity (Ωcm)
0.06
0.05
0.04
0.03
0.02
0.01
0.00
50
100
150
200
250
300
350
Temperature (K)

FIG. 5

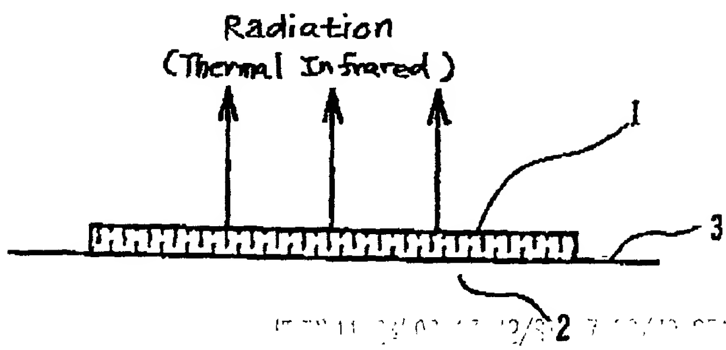
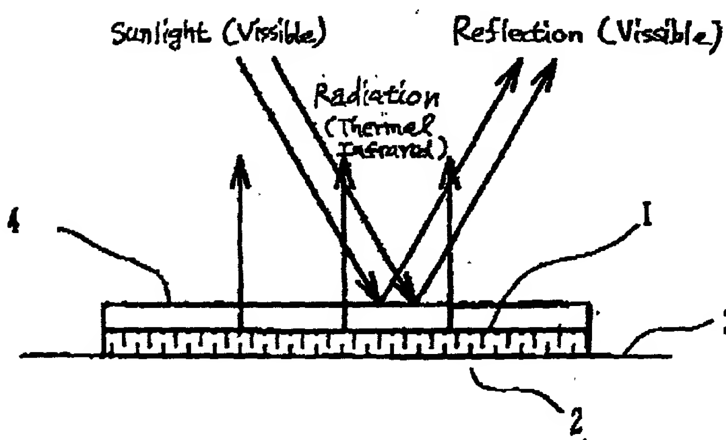

Radiation
(Thermal Infrared)
I
3
2

FIG. 6


Sunlight (Vissible)
Reflection (Vissible)
Radiation
(Thermel
Infrared)
4
I
3
2

Application for United States Patent

DECLARATION AND POWER OF ATTORNEY

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name;

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled "HEAT CONTROL DEVICE"

the specification of which:

(check one)

☒ is attached hereto

☐ was filed on ________________, as Application Serial No. __________ and was amended on __________. (if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, § 1.56*

I hereby claim foreign priority benefits under Title 35, United States Code, § 119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s)

(Number)	(Country)	(Day/Month/Year Filed)	priority claimed yes	no
322549/1997	Japan	25/11/1997	X	
274826/1998	Japan	29/09/1998	X	

I hereby claim the benefit under Title 35, United States Code, § 120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, § 112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, § 1.56 which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

(Application Serial No.)	(Filing Date)	(Status: patented, pending, abandoned)

Power of Attorney: As a named inventor, I hereby appoint C. Lamont Whitham, Reg. No. 22,424, Marshall M. Curtis, Reg. No. 33,138, and Michael E. Whitham, Reg. No. 32,635, Reg. 34,386 as attorneys and/or agents to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. All correspondence should be directed to Whitham, Curtis & Whitham, Reston International Center, 11800 Sunrise Valley Dr., Suite 900, Reston, Virginia 20191. Telephone calls should be directed to Whitham, Curtis & Whitham at (703) 391-2510.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full Name of Sole or First Inventor Akira OKAMOTO

Inventor's Signature Akira Okamoto Date November 20, 1998

Residence Tokyo, Japan

Citizenship Japan

Post Office Address c/o NEC Corporation, 7-1, Shiba 5-chome, Minato-ku, Tokyo, Japan

Full Name of Second Joint Inventor, If Any Yuichi SHIMAKAWA

Inventor's Signature Yuichi Shimakawa Date November 20, 1998

Residence Tokyo, Japan

Citizenship Japan

Post Office Address c/o NEC Corporation, 7-1, Shiba 5-chome, Minato-ku, Tokyo, Japan

Full Name of Third Joint Inventor, If Any Takashi MANAKO

Inventor's Signature Takashi Manako Date November 20, 1998

Residence Tokyo, Japan

Citizenship Japan

Post Office Address c/o NEC Corporation, 7-1, Shiba 5-chome, Minato-ku, Tokyo, Japan

Full Name of Fourth Joint Inventor, If Any

Inventor's Signature Date

Residence

Citizenship

Post Office Address

Full Name of Fifth Joint Inventor, If Any

Inventor's Signature Date

Residence

Citizenship

Post Office Address

*Title 37, Code of Federal Regulations, § 1.56:

(a) A patent by its very nature is affected with a public interest. The public interest is best served, and the most effective patent examination occurs when, at the time an application is being examined, the Office is aware of and evaluates the teachings of all information material to patentability. Each individual associated with the filing and prosecution of a patent application has a duty of candor and good faith toward the Patent and Trademark Office, which includes a duty to disclose to the Office all information known to that individual to be material to patentability as defined in this section. The duty to disclose information exists with respect to each pending claim until the claim is canceled or withdrawn from consideration, or the application becomes abandoned.

(b) Under this section, information is material to patentability when it is not cumulative to information already of record or being made of record in the application, and (1) it establishes, by itself or in combination with other information, a prima facie case of unpatentability; or (2) it refutes, or is inconsistent with, a position the applicant takes in: (i) opposing an argument of unpatentability relied on by the Office, or (ii) asserting an argument of patentability.